POCKET GOPHERS (*THOMOMYS TALPOIDES*) IN SUCCESSIONAL STAGES OF SPRUCE-FIR FOREST IN IDAHO

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Abstract.— This study examined (1) the relative abundance of the pocket gopher (*Thomomys talpoides*) in four successive stages (1–10, 11–39, 40–79, and 80+ years following disturbance) of spruce-fir forest; (2) the relationship between number of gopher sign (mounds and earth plugs) with gopher density; and (3) a method of sampling pocket gopher populations using a 500 by 4 m strip transect. The number of gopher mounds was significantly correlated with the number of earth plugs. Data were pooled and a categorical log linear analysis used to test for significant differences in pocket gopher sign between the four successive stages. The 1–10 and the 80+-year-old sites had significantly more gopher sign than the 11–39 and the 40–79-year-old sites. No significant differences were found between the 11–39 and the 40–79-year-old sites, or between the 1–10 and the 80+-year-old sites. The difference in population densities may be due to understory vegetation differences between the successional stages. There was a significant correlation between amount of gopher sign and gophers caught in each of the study sites. This indicates that counts of pocket gopher sign may be used to estimate pocket gopher density. The strip transect is recommended as the most appropriate method when sampling heterogeneous habitats or when there is cause to suspect gopher populations may be aggregated within the area rather than spaced randomly or regularly.

The economic importance of the pocket gopher (Geomyidae) is rarely disputed. Some regard them as beneficial in water conservation, aeration, deepening and fertilization of mountain soils (Grinnell 1923, Grinnell and Storer 1924, Taylor 1935, Storer 1947, Ellison and Aldous 1952). Others condemn them for damaging cultivated orchards (Wight 1930), inhibiting reforestation practices (Moore 1943, Tevis 1956, Crouch 1971), and increasing soil erosion (Day 1931, Gabrielson 1938, Peck 1941).

Most literature on pocket gophers refers to studies in nonforest vegetation communities. Few have studied gophers in seral stages of forest succession, and the conclusions of those who have are generally speculative or inconclusive (Davis et al. 1938, Ellison 1946, Ingles 1949). Ellison (1946) reported that most *Thomomys talpoides* activity is restricted to herbaceous vegetation and is essentially absent from areas of spruce-fir timber. Davis et al. (1938) found only small numbers of *Geomys breviceps* in timbered areas, with large numbers in open pastures. Ingles (1949) suggested that *Thomomys monticola* prefer meadows, but, as winter approaches, gophers living in meadows move beneath trees, where humus soils allow better drainage and prevent soil from freezing. In contrast, research preliminary to this study indicated that population densities of *T. talpoides* during the summer in a mature spruce-fir forest were greater than densities of gophers in early, more open, successional stages.

One problem in studying pocket gophers is the lack of a rapid and reliable census method. Mound counts have been used (Mohr and Mohr 1936, Phillips 1936, Davis et al. 1938, Ellison and Aldous 1952, Julander et al. 1959, Howard 1961), but the validity of this method has been criticized (Richens 1965, Ingles 1949). Reid et al. (1966) proposed a method for approximating populations by counting new sign (mounds, mound clusters, and earth plugs) that appeared within a two-day interval. Following an intensive "trap-out" of the study plots, they determined there was a significant correlation between the number of gophers and the number of new sign appearing in the two-day interval. Reid et al. (1966) concluded that "the relationship between numbers of pocket gophers and ground surface sign should be determined for each new situation and season, vegetation type, and species of pocket gopher where inventory work is planned."

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The objectives of this study were to (1) determine the relative abundance of the pocket gopher (*Thomomys talpoides*) in four successional stages of spruce-fir forest; (2) determine if a relationship existed between the number of pocket gopher mounds and earth plugs with gopher density; and (3) discuss a method of sampling pocket gopher populations using a 500 by 4 m strip transect.

Study Area

Study areas were located within the Pierce Ranger District of the Clearwater National Forest in Idaho. U.S. Forest Service records were consulted and study sites selected that represent a successional range from clear-cut to mature climax in the spruce-fir association. Two stands (referred to as group I and II) of each age class, 1–10, 11–39, 40–79, and 80+ years following disturbance were selected. Elevation of the study sites ranged from 708 to 1539 m. Although disturbance of the sites during the study was negligible, human activity in the Pierce District was considered high, particularly in the form of logging activity and, to a lesser extent, recreational activity. On the 1–10-year-old sites, Fireweed (*Epilobium augustifolium*) was the dominant forb, with Elderberry (*Sambucus sp.*) and Snowbrush (*Ceanothus velutinus*) the dominant shrubs. In the 11–39 and the 40–79-year-old sites, Heart-leaved Arnica (*Arnica cordifolia*) and Twin-flower (*Linnaea borealis*) were dominant forbs and Scouler Willow (*Salix scouleriana*) and Honeysuckle (*Lonicera utahensis*) were dominant shrubs in the 11–39-year-old sites. The dominant shrub in the 40–79-year-old sites was Huckleberry (*Vaccinium membranaceum*). Wild Ginger (*Asareum caudatum*) was the dominant forb in the 80+-year-old sites and Huckleberry (*V. membranaceum*) the dominant shrub. In all successional stages, Grand Fir (*Abies grandis*) was the dominant tree species.

Methods

Because pocket gopher activity is generally highest in late summer to early fall (Miller 1948, Miller and Bond 1960, Reid et al. 1966), data were gathered during August 1979. Fifty quadrats, each 4 m in diameter, spaced 10 m apart along a 500 m randomly established transect, were analyzed for pocket gopher activity in each of the eight study sites. Mounds and earth plugs were recorded as evidence of pocket gopher activity. Mounds are soil that gophers excavate while burrowing. When two mounds overlapped more than 50 percent, they were considered as one. Earth plugs, circular openings filled with loose soil and generally considered to result from gophers exploring the surface for food, were frequent (Grinnell 1923).

At each point along the transect a modified point quarter procedure (Phillips 1959) was implemented to gather data on shrub composition. The height of the tallest shrub 2 m from the point was measured within each quarter. When no shrubs were present within the 2 m interval, the tallest shrub within 4 m was measured. Shrubs were classified into one of three categories based on shrub height: Class I: Trace–114 cm, Class II: 115–190 cm, Class III: $>$ 190 cm. A categorical log linear analysis technique (Bishop 1975, Feinberg 1977) was used to test separately for significant differences in abundance of sign of pocket gopher and shrub composition in the four successional stages of forest.

The Ocular Method (Daubenmire 1968) was used to measure percent forbs (by species). This method utilizes the concept that one can accurately estimate broad coverage classes even though the observer may not be able to estimate the precise cover parameter for any quadrate very accurately. Using a multiple comparison procedure described by Dunn (1964) and Gibbons (1976), simultaneous statements of statistical differences were made comparing all possible combination sets of total forb cover of two successional stages. In using this procedure the overall levels of significance are frequently larger than numbers ordinarily used in an inference involving a single comparison. We followed Gibbons's (1976) recommendation of setting α at 0.02 when comparing four populations.

To correlate pocket gopher numbers with sign, a procedure described by Reid et al. (1966) was modified and implemented. Whereas Reid et al. (1966) used 40,000 ft^2 (12,121 m^2) plots, this study involved use of a rectangle plot. Approximately one week after the initial inventory of transects was made, the transects were again traversed and all pocket gopher sign leveled within 2 m of each side of the transects. This resulted in a strip transect 500 by 4 m, or 0.2 ha. Twenty-four hours after the sign was leveled, the transects were examined for new pocket gopher sign and trapped intensively with Macabee traps. The traps were operated for three days to assure that all or most animals were trapped. Data from the eight study sites were pooled and a regression analysis performed to correlate pocket gopher numbers with sign produced by the animals.

Results

For the eight study sites, the number of pocket gopher mounds was significantly correlated ($P < 0.05$) with the number of earth plugs (Fig. 1). This allowed the mound and earth plug data to be pooled for subsequent analyses of gopher populations.

Relative abundance of pocket gopher sign in each successional stage was examined (Fig. 2). With four successional stages of interest, three statistical comparisons were made: (1) the 1–10 and the 80+ with the 11–39 and the 40–79-year-old sites, (2) the 11–39 with the 40–79-year-old sites, and (3) the 1–10 with the 80+-year-old sites. The first contrast indicated the 1–10 and the 80+-year-old sites had significantly ($P < 0.05$) more pocket gopher sign than the 11–39 and the 40–79-year-old sites. Although no significant difference was found between the 11–39 and the 40–79-year-old sites, there was a tendency for the 40–79 age class to have more sign than the 11–39. Finally, the 1–10 and the 80+-year-old sites did not differ significantly and there was little tendency for one successional stage to have more pocket gopher sign than the other.

Because the count of mounds and earth plugs for use in predicting pocket gopher densities had been criticized, we were interested in the predictive value of these counts in spruce-fir forests in Idaho. Counts of gopher sign, total number of gophers captured, and the number of gopher sign/gophers caught using the modified Reid et al. (1966) method as previously described are shown in Table 1. These data indicate an average of 2.5 (± 1.2) sign of gopher made for each gopher. The number of observed sign of gopher was significantly correlated ($P < 0.05$) with the number of pocket gophers caught (Fig. 3). Thus, for this area in Idaho, sign of pocket gophers may be used as a rapid and reliable means of estimating pocket gopher populations.

Of three shrub classes (Class I: Trace–114 cm, Class II: 115–190 cm, Class III: > 190 cm), early and late successional stages had significantly ($P < 0.05$) more Class I shrubs and fewer Class III shrubs than midsuccessional stages. Total forb cover was relatively

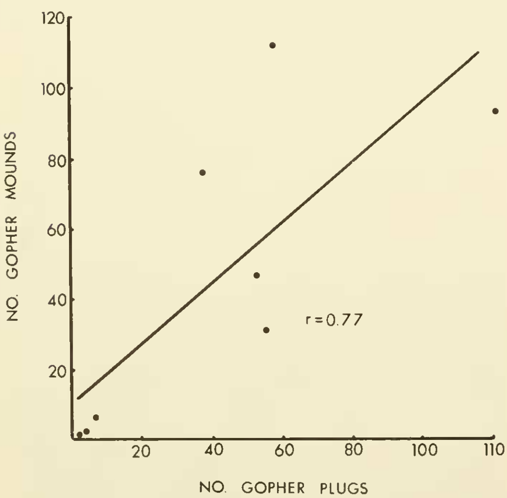

Fig. 1. Correlation of the number of pocket gopher mounds with the number of earth plugs.

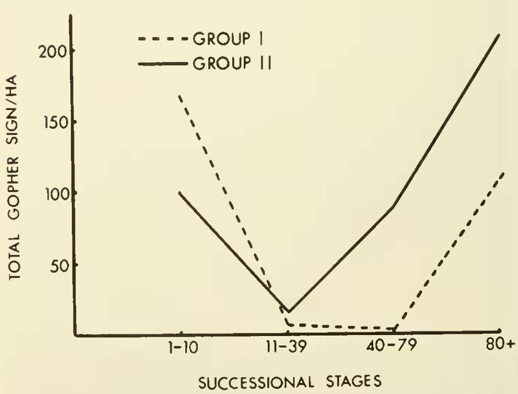

Fig. 2. Total number of pocket gopher signs (mounds and earth plugs)/ha in two groups of four successional stages.

Table 1. Total number of gopher sign (mounds and earth plugs), total gophers caught, and the number of gopher sign produced in two groups of four successional stages during August 1979.

Successional stage	Number gopher sign	Number gophers trapped	Number sign/ gopher
1–10[a] I[b]	39	15	2.6
1–10 II	16	8	2.0
11–39 I	1	1	1.0
11–39 II	15	10	1.5
40–79 I	3	1	3.0
40–79 II	55	16	3.4
80+ I	24	5	4.8
80+ II	35	22	1.6
Total	188	78	2.5

[a]Years following disturbance.
[b]Group designation.

Table 2. Results of Dunn's (1964) multiple comparison test forb cover in two groups of four successional stages. Underlined successional stages do not differ significantly (α = 0.20). Percent forb cover is also included.

Group I	11–39[a]	80+	1–10	40–79
Total forb cover(%)	27.1	30.0	41.2	46.7
Group II	11–39	1–10	40–79	80+
Total forb cover (%)	34.1	39.6	40.8	47.6

[a]Years following disturbance.

constant in all successional stages (Table 2). In group I sites there were no significant differences in forb cover of the 1–10, 40–79, and 80+-year-old sites; however, these sites contained significantly greater cover than the 11–39-year-old site. In group II sites the 80+-year-old site contained significantly more forb cover than the 11–39-year-old site, but other sites did not differ significantly.

Discussion

Several authors (Scheffer 1931, Crouch 1933, Miller 1948, Laycock 1957, Miller and Bond 1960, Howard and Childs 1959) have reported that burrowing activity of pocket gophers varies seasonally. Most agree that activity is highest in spring, tapers to a low in summer, increases in late summer to early fall, then stabilizes to a moderate level through winter. Some (Crouch 1933, Miller 1948, Laycock 1957) attribute variation in observed burrowing to fluctuations in soil moisture and soil temperature. Others (Miller and Bond 1960, Reid et al. 1966) found little correlation between burrowing and soil moisture and suggest that late summer burrowing activity represents behavioral changes associated with dispersal of young. Reid et al. (1966) noted that because of this seasonal difference in rate of sign made by pocket gophers, results of sign counts in summer would differ from those in fall. Pocket gopher densities based on midsummer sign counts would be underestimated and more accurate estimates would be expected as fall approaches. Data were gathered in August, and there was a good correlation between estimates of pocket gopher density and sign counted.

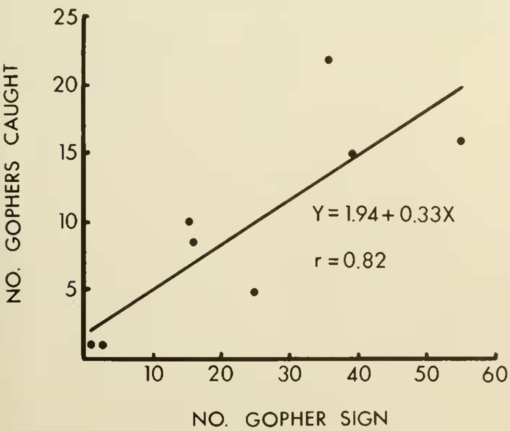

Fig. 3. Number of observed sign of pocket gopher correlated with number of pocket gophers caught in two groups of four successional stages.

Much of the literature dealing with pocket gophers in forest ecosystems refers primarily to the abundance and role of gophers with respect to early stages of reforestation (Dingle 1956, Garrison and Moore 1956, Tevis 1956, Crouch 1971, Hooven 1971). It is not surprising, therefore, to find pocket gophers in particularly high numbers in early successional stages, but the high density of pocket gophers in the mature forest was neither really known nor expected. While a definitive explanation of this distribution is not intuitively obvious, some suggestions may be offered.

Gopher distribution could be influenced by vegetation differences between seral stages. Early and late stages had more small shrubs and fewer tall shrubs than midsuccessional stages due to the increased woody root system of large shrubs. *Thomomys talpoides* prefer deep, rich, tractable soils (Miller 1964).

Though the soil in these midsuccessional stages may be deep and rich, gophers may find the root-laden soil unfavorable for burrowing.

In addition, pocket gophers prefer herbaceous vegetation for food. Although there were few significant differences in total forb cover among the successional stages, the sites differed in species composition. *Thomomys talpoides* could prefer forbs in early and late successional stages. Motyka's et al. (1950) similarity index indicated that the 11–39 and the 40–79-year-old sites were most alike, i.e., had the greatest similarity index, in both groups of successional stages. The smaller population densities of gophers in midsuccessional stages could be attributed to less palatable forbs these sites have in common.

Although the relative distribution of shrubs and herbs within the four successional stages may be the most apparent explanation of pocket gopher distribution, other less obvious habitat differences may be equally important. Such soil characteristics as temperature, moisture, pH, texture, and profile may differ between successional stages and influence gopher distribution.

The final objective of this study was to discuss the strip transect method of sampling pocket gopher populations. Theoretically, plot size can influence the variance of the sample mean (and thus cost required to achieve an adequate sample size), relative border decisions, ease of establishing a permanently marked plot, and movement required to observe plot contents (Curtis and McIntosh 1950, Cottam et al. 1955, 1957). The first effect of plot shape (i.e., influence on variance of the sample mean) would not be expected to be a problem in a relatively homogeneous habitat where pocket gopher poulations may be randomly or regularly distributed. In a heterogeneous habitat, however, gopher populations may be aggregated into favorable microhabitats. In this case, there is a strong likelihood that isodiametric plots may fully include or not include aggregations of gopher populations. In contrast, the strip transect is more likely to sample regions of differing degrees of aggregation. Theoretically, one would thus expect the strip transect plot to have a smaller variance than would isodiametric plots of comparable size.

Though the variance may be smaller with the strip transect, greater movement of the researcher may be necessary to determine whether to include a specific gopher sign. As the length of the transect increases, the number of border decisions increases. Such decisions take time and increase the likelihood of sampling bias.

This method of sampling pocket gopher populations requires permanently marked study plots. Although it is somewhat easier to permanently mark square or round plots, we had little difficulty marking the strip transect and judging any marking differences inconsequential.

In summary, when studying pocket gopher populations, we recommend, on a theoretical basis, the strip transect as most appropriate when sampling heterogeneous habitats or when there is cause to suspect gopher populations to be aggregated within the area of interest rather than randomly or regularly spaced.

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